HEALTH MANAGEMENT INFORMATION SYSTEMS

Principles, Applications, and Analytics

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Book Summary

This comprehensive textbook delivers an in-depth exploration of **Health Management Information Systems (HMIS)** a critical component for improving healthcare outcomes in the digital age.

Tailored for health professionals, students, policy-makers, and administrators, the book begins with foundational concepts, linking data, information, and knowledge to decision-making in health systems. It covers the architecture of HMIS, including WHO's building blocks, and explains key applications in clinical, administrative, and financial settings.

With practical examples, interactive activities, and case-based analysis, this book equips readers with tools to analyze immunization data, evaluate diagnostic tests, understand data governance, and navigate ethical, legal, and security concerns. Advanced topics like decision-support systems, EHR integration, and public health analytics are also covered.

Whether you're improving an existing HMIS or designing one from the ground up, this book offers the principles and strategies needed to deliver better health through better data.

Finally, the book presents challenges to implementation such as data redundancy, user resistance, and cost constraints while offering solutions through interoperability, training, and policy alignment.

Health Management Information Systems equips readers with the principles, tools, and real-world frameworks needed to build, analyze, and apply HMIS effectively in diverse health systems globally.

Dedication

To my beloved family, whose unwavering support, patience, and encouragement have been the cornerstone of my journey.

This work is dedicated to the health professionals and educators who tirelessly work to improve health systems around the world.

Acknowledgement

I extend my deepest gratitude to all those who contributed to the development of this book.

To my mentors, colleagues, and peers—your insights and guidance have shaped this work into a valuable resource.

Special thanks to the healthcare professionals and administrators who shared their real-world experiences, which greatly enriched the content.

To my family, thank you for your unwavering support and belief in my mission to contribute to global health management.

Finally, I acknowledge the countless health workers around the world whose dedication inspires this work.

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1. Foundational Concepts

1.1. Introduction

Health Management Information System is an essential tool to assist health care managers and health service delivery staff to monitor the performance, quality and health care activities and reach logical decisions for improving health care delivery.
The health information system provides the underpinnings for decision-making and has four key functions: data generation, compilation, analysis and synthesis. The health information system collects data from the health sector and other relevant sectors, analyses the data and ensures their overall quality, relevance and timeliness, and converts data into information for health-related decision-making.
HMIS is used by the health unit in-charge and the Health Unit Management Committee to plan and coordinate health care services in their catchment area [1].

1.2. HMIS Components and Basic Functions

Data: Constitute representations of information, or knowledge in a formalized manner suitable for communication, interpretation, or processing by humans or machines (e.g., discrete characters, continuous signals).
Information: is specific knowledge about entities such as facts, events, things, persons, processes, ideas, or concepts.
Knowledge: is general information about concepts in a certain domain (scientific or professional) (e.g., about diseases, therapeutic methods
A system: is a set of persons, things, and or events that work together to achieve a common objective (e.g., a hospital is a man-made system consisting of staff, patients, and their interactions).

Information: Meaningful collection of facts or Data

Information system: A system that provides information support to the decision-making process at each level of an organization.

Hospital Information Systems: (HIS) are dealing with processing data, information and knowledge in health care environments.

Health Management Information System: is a system of record-keeping, reporting, processing, analyzing, interpretation of information.

A group of two or more legally separated health care institutions that have temporarily and voluntarily joined together to achieve a common purpose are defined as **Health Care Network.**

The information system of a health care network is called a Transinstitutional Health Information System.

Health information system can be differentiated in institutional health information system, e.g., hospital information systems, and transinstitutional health information systems that span the borders of two or more legally separated institutions.

Transinstitutional health information systems play a vital role in supporting integrated care.

The issue is not that we need more data, but better use of data [2].

Five major components of HMIS:

1. Data/information/knowledge
2. Hardware/software/network
3. Process/task/system
4. Integration/interoperability
5. User/administration/management

Processed data are transformed into information that serves as useful output for HMIS end-users to make informed and intelligent decisions [3].

1. 📊 *Activity: Create a concept map linking data, information, knowledge, and HMIS components.*
🧠 Reflection *Prompt: Describe a real-life situation in healthcare where data was available but not transformed into actionable knowledge.*

1.3. Purposes of HMIS:

The purpose of HMIS is to routinely generate quality health information and use that information for management decisions to improve the performance of health services delivery.

Purposes of HMIS:

Evidence-Based Decision Making

- Monitoring and evaluation of control programs
- Plan actions, programs, and resources
- To prioritize the allocation of health resources
- To provide the basis for epidemiological research
- Accountability

The most important enterprise functions in health care are related to diagnostics and therapy. Obviously, data that are relevant to medical decision making need to be collected and presented in a patient record.

Use HMIS data/information: calculating, analyzing, interpreting,

Coverage rates: shows the percentage of a target population.

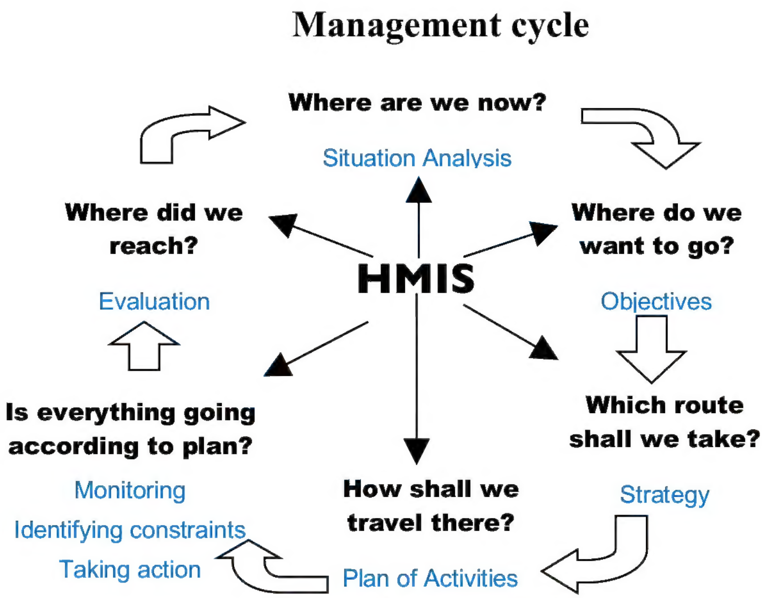


Figure 1 Management Cycle

2. - Drag-and-Drop (digital): Arrange the steps of the management cycle in the correct order.
❓📁 *Case Question: A clinic is underperforming in immunizations—what stage of the cycle should they focus on?*

Information sources of health information system:

Census
Surveys Registrations
Tally
HMIS
Program Statistics
Patient Registers
Morbidity
Mortality
Antenatal
Causes of death reported daily,
Percentage of births registered
Percentage of death registered

3. 📄✏️ Worksheet: Categorize health data sources as primary, secondary, or administrative.
- Mini-Research Prompt: Look up your country's health data sources and identify any gaps in data collection.

HMIS provides information on:

- Health status (nutritional, morbidity, mortality), and Health services

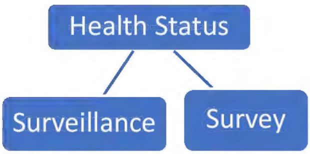


Figure 2 Health Status

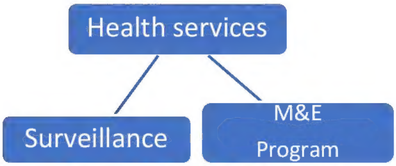


Figure 3 Health Service

HMIS cons:

- ❖ Too much collected data
- ❖ No guidelines
- ❖ No enough skills

- No enough staff
- Low quality of information
- Fragmentation of information

Good planning can prevent problems. Some problems need immediate decision and solutions, while others are less urgent or may demand resources beyond what is available.

2. HMIS Architecture and Design

2.1. Building Blocks

The building blocks of a Health Management Information System (HMIS) are the fundamental components that ensure its effective function and contribute to the overall health system's strength. These blocks, as defined by the World Health Organization (WHO), include service delivery, health workforce, health information systems, access to essential medicines, health system financing, and leadership and governance.

Six building blocks for health system strengthening diagram

Block diagram 1 HMIS building blocks

- **Health Service Delivery:** This block focuses on the quality and accessibility of healthcare services, ensuring that people receive the right care, at the right time, and in the right place.
- **Health Workforce:** A well-trained, motivated, and adequately resourced health workforce is essential for delivering effective services.
- **Health Information Systems:** HMIS is a crucial part of this block, providing reliable and timely data for planning, management, and decision-making.
- **Access to Essential Medicines:** Ensuring equitable access to affordable and high-quality medicines is vital for effective healthcare.
- **Health System Financing:** Adequate and sustainable funding is necessary to support all other building blocks.
- **Leadership and Governance:** Strong leadership and effective governance are crucial for coordinating and managing the health system as a whole.

In essence, HMIS is one of the key building blocks that helps to strengthen the overall health system by providing the data and information needed to monitor performance, improve services, and make informed decisions [4].

4. - Diagram Labeling: Label a blank version of WHO's six building blocks.
💬🗣️ *Discussion Prompt: Which building block do you think is most challenging in your country's health system, and why?*

2.2. Characteristics of a strong HMIS

HMIS architecture can be centralized or decentralized. A well-designed HMIS includes:

1. Data input modules
2. Secure databases

3. Reporting dashboards
4. Integration with other systems like EHRs
5. Leadership with roles and responsibilities
6. Strategy Plan
7. Health indicators
8. Population statistics and population survey data
9. Covers all health programs includes key health inputs (HR, Logistics and Finance) [5].

5. ✅📝 Checklists: Does your local HMIS include these 9 characteristics? (Self-assessment)
🧩🔗 Matching Game: Match each feature (e.g., 'reporting dashboards') with its benefit.

3. Quantitative analysis of local immunization data

The first step for all health facilities is to analyze data. Table 1 should be completed as described below. In this guide we have made certain assumptions which you can change according to the national situation.

Dropout Rate: shows the percentage of invents who started receiving immunizations but never received all doses in a series.

Fully immunized refers that the child who received all due vaccine till one year of age.

Completely immunized: A child who has received all due vaccine till two years of age. The table below shows Routine Immunization Analysis.

Column a:	Target population <1 year	Write the number of infants less than one year of age in each of the areas. Note that for this guide the number of pregnant women is the same as the number of infants.
Column b:	Doses of Penta1 administered	Write the number of doses of Penta1 administered to infants in each area.

Column c:	Doses of Penta3 administered	Write the number of doses of Penta3 administered to infants in each area.
Column d:	Doses of measles vaccine administered	Write the number of doses of measles vaccine administered to infants in each area.
Column e:	Immunization coverage Penta1 (%)	Divide the doses of Penta1 administered (**b**) by the target population <1 year (**a**) and multiply by **100**. $\mathbf{e} = \frac{b}{a}$ **x 100**
Column f:	Immunization coverage Penta3 (%)	Divide the doses of Penta3 administered (**c**) by the target population <1 year (**a**) and multiply by **100**. $\mathbf{f} = \frac{c}{a}$ **x 100**
Column g:	Immunization coverage measles vaccine (%)	Divide the doses of measles vaccine administered (**d**) by the target population <1 year (**a**) and multiply by **100**. $\mathbf{g} = \frac{d}{a}$ **x 100**

Column h:	Unimmunized with Penta3	Subtract the doses of Penta3 administered (**c**) from the target population <1 year (**a**) **k =a−c**
Column i:	Unimmunized with measles vaccine	Subtract the doses of measles vaccine administered (**d**) from the target population <1 year (**a**) **i =a−d**
Column j:	Drop-out rates Penta1 to Penta3 (%)	Subtract the doses of Penta3 (**c**) from the doses of Penta1 (**b**), divide by the doses of penta1 (**b**) and multiply by **100** $\mathbf{j} = \frac{b-c}{b} \times 100$
Column k:	Drop-out rates Penta1 to measles vaccine (%)	Subtract the doses of measles vaccine (**d**) from the doses of Penta1 (**b**), divide by the doses of Penta1 (**b**) and multiply by **100.** $\mathbf{n} = \frac{b-d}{b} \times 100$

Table 1 Routine Immunization Analysis [6]

6. ➗🧠 Calculation Exercise: Given sample data, calculate immunization coverage, drop-out rates, and unimmunized counts.

🛠️ Scenario: Data shows a high Penta1-to-Penta3 dropout—what could be the cause?

4. Applications of HMIS:

A patient record in general is composed of all data and documents generated or received during the care of a patient at a health care institution.
Hospital function includes patient admission, patient treatment, order entry, execution of procedures, clinical documentation, administrative documentation, patient discharge, handling of patient record, resource planning and work organization, and hospital administration are all played significant role for hospital organizing, therefore the patient record is an amalgam of all the data acquired and created during a patient's course through the health care system. Health Management Information System (HMIS) applications can be classified into clinical, administrative, and financial categories, which contain different tools such as Electronic Medical Records (EMRs) and Electronic Health Records (EHRs), Practice Management Software, and Master Patient Indexes, among others. The purpose of a patient record is "to recall observations, to inform others, to instruct students, to gain knowledge, to monitor performance, and to justify interventions.

Figure 4 EHR Display

4.1. Clinical Applications:

4.1.1. The Electronic Health Record (EHR): is the collection of medical data relating to one patient that is stored in the computer-supported part of a health information system. EHRs are needed to support functions of patient care as well as for administrative functions.

4.1.2. Remote Patient Monitoring (RPM): enables continuous monitoring of patients' health data from a distance, often using wearable devices and sensors.

4.1.3. Clinical Decision Support (CDS): Provides clinicians with tools and information to aid in diagnosis and treatment decisions.

4.2. Administrative Applications:

4.2.1. Practice Management Software: Helps manage daily operations like scheduling, billing, and insurance claims.

4.2.2. Patient Portals: Provide patients with secure online access to their health information, appointment scheduling, and other services.

4.2.3. Registration and Queue Management: Handles patient registration, scheduling, and appointment management.

4.3. Financial Applications:

4.3.1. Medical Billing: Manages the billing process for patient services, including insurance claims and payments.

4.3.2. Financial Systems: Handle accounting, budgeting, and financial reporting within a healthcare organization.

The paper record: Pros

- Portable
- Familiar and easy to use

– Exploits everyday skills of visual search, browsing etc.

- Natural: “direct” access to clinical data – Handwriting

– Charts, graphs
– Drawings, images…

The paper record: Drawbacks

• Can only be used for one task in a single time and that can lead to long waits.
• Records can get lost.
• Consume space.
• Large individual records are hard to use.
• Fragile and susceptible to damage.
• Environmental cost.

Figure 5 Paper Record

Electronic health records: pros

• Compact
• Simultaneous use
• Easily copied/archived
• Portable (handheld and wireless devices)
• Secure
• Supports many other services – Decision support
– Workflow management
– Performance audits
– Research [7].

Electronic health records: Drawbacks

• High capital investment
– Hardware, software, operational costs – Transition from paper to computer
• Training requirements
• Power outs – the whole system goes down!
• Continuing security debate
– Stealing one paper record is easy, 20 is harder, 10,000 effectively impossible – the security risks are very different for electronic data.

7. 🧐📚 Case Study Analysis: Compare two clinics—one using paper records, one using EHRs. Identify pros/cons.
- Role Play: You're a clinic manager implementing EHR—how would you train your staff?

5. Challenges of Health Information Systems:

1. Challenge of user acceptance. Health care professionals have the problem of having to use a set of application components, often with different user interfaces, overlapping features and separate user identification procedures. This is time-consuming and potentially dangerous for the patient, as important data may not be available when needed, leading to wrong diagnostic or therapeutic decisions.
2. Challenge of data redundancy. As different health care professionals often need the same data, heterogeneous information systems typically lead to data duplication: Relevant data may be documented several times at different sites and or by different providers.
3. Challenge of transcription. In heterogeneous architectures there is a considerable amount of transcription, i.e., the transfer of data from one storage device to another (e.g., the transfer of a patient's diagnoses from the patient record to an order entry form).
4. Challenge of costs. Too high, in particular uncontrolled redundancy causes considerable additional maintenance costs for updating replicate data in (redundant) databases.
5. Challenge of privacy and security. Patients' health data belong to the most sensitive data about humans. For this reason, individual patient data must only be accessible to those persons the patient authorized before.

Quick access to summary information about a patient.
The patient's active medical problems, current medications, and drug allergies are among the core data that physicians must keep in mind when making any decision on patient care. This one-page screen provides an instant display of these core clinical data elements as well as reminders about required preventive care.

8. 🤔 Problem-Solution Matching: Match each challenge (e.g., data redundancy) with a best practice solution.
💬🗣️ *Discussion Prompt: Which of these challenges have you seen in practice? What was done to address it?*

6. Key Concepts in Diagnosis Evaluation

Population with affected and non-affected individuals

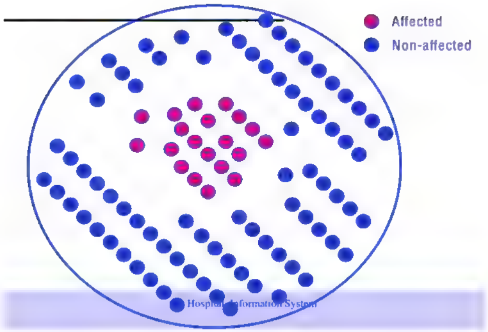


Figure 6 Affected & non-Affected Population

A perfect diagnostic test identifies the affected individuals only

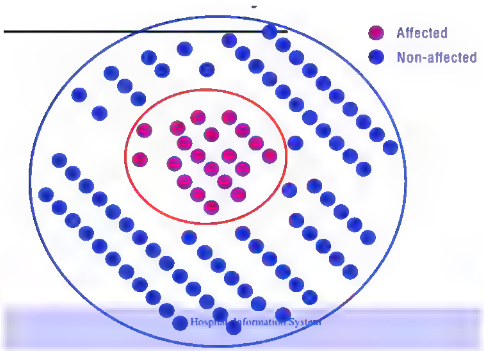


Figure 7 Perfect diagnosis

In reality, tests are not perfect

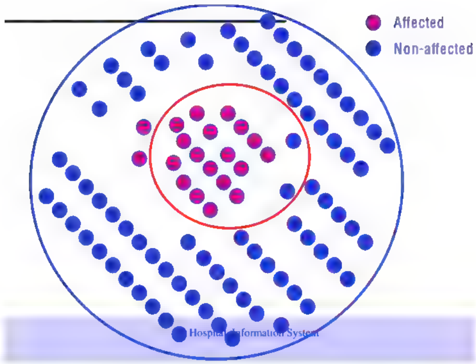


Figure 8 Not Perfect tests

Sensitivity of a test

The sensitivity of a test is the ability of the test to identify correctly the affected individuals

Proportion of persons testing positive among affected individuals

		Affected persons
Test result	+	True positive (TP)
	–	False negative (FN)

Sensitivity (Se) = TP / (TP + FN)

Equation 1 Sensitivity Eq

Estimating the sensitivity of a test

- Identify affected individuals with a gold standard
- Obtain a wide panel of samples that are representative of the population of affected individuals

– Recent and old cases
– Severe and mild cases
– Various ages and sexes

- Test the affected individuals
- Estimate the proportion of affected individuals that are positive with the test

Specificity of a test

The specificity of a test is the ability of the test to identify correctly non-affected individuals

Proportion of persons testing negative among non-affected individuals

		Non-affected persons
Test result	+	False positive (FP)
	–	True negative (TN)

Specificity (Sp) = TN / (TN + FP)

Equation 2 Specificity Eq

Estimating the specificity of a test

- Identify non-affected individuals.
  – Negative with a gold standard.
  – Unlikely to be infected.
- Obtain a wide panel of samples that are representative of the population of non-affected individuals.
- Test the non-affected individuals.
- Estimate the proportion of non-affected individuals that are negative with the test.

Prevalence is the proportion of a population who have a specific characteristic in a given time period.

- To estimate prevalence, researchers randomly select a sample (smaller group) from the entire population they want to describe. Using random selection methods increases the chances that the characteristics of the sample will be representative of (similar to) the characteristics of the population.
- For a representative sample, prevalence is the number of people in the sample with the characteristic of interest, divided by the total number of people in the sample.

$$\text{Prevalence} = \frac{\text{Number of people in sample with characteristic}}{\text{Total number of people in sample}}$$

Equation 3 Prevalence Eq

9. ✍️🧮 Practice Problem: Given TP, FP, FN, TN values—calculate sensitivity and specificity.
- Diagram Sketching: Draw your own diagram of perfect vs. imperfect test outcomes.

7. Decision-Support and Evaluation Tools

A clinical decision-support system is any computer program designed to help health professionals make clinical decisions.

In a sense, any computer system that deals with clinical data or medical knowledge is intended to provide decision support.

Clinical decision support systems: are active knowledge systems which use two or more items of patient data to generate case-specific advice [8].

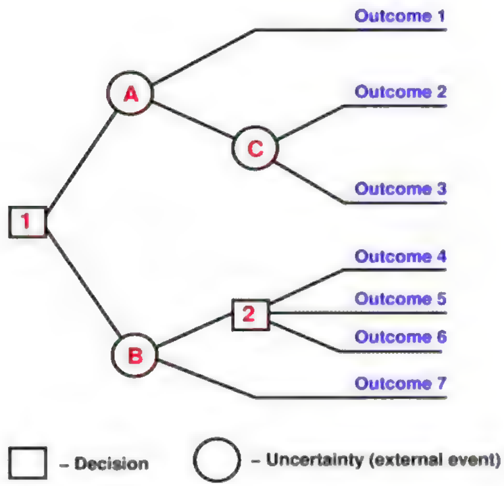
Main components:

– Medical knowledge

– Patient data

– Case-specific advice

Decision Tree: A decision tree is a visual tool that maps out possible decisions and their potential outcomes, including probabilities and consequences, in a tree-like structure. It helps in analyzing different courses of action and making informed choices.



Block diagram 1 Decision tree

The tree helps quantify the **expected value** of each choice, guiding patients and clinicians toward the option with the highest expected benefit.

This kind of diagram is typically used to **model sequential decisions under uncertainty**, where the outcomes depend both on decisions and random events.

Example: Decision Tree

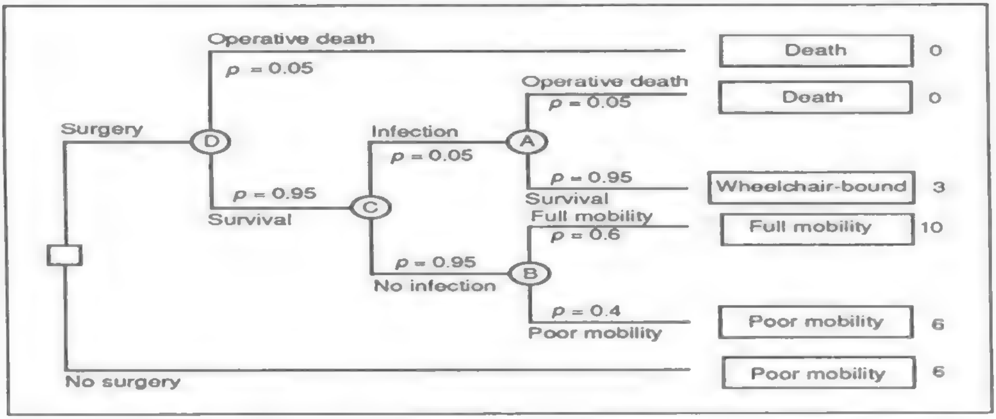


FIGURE 3.10. Decision tree for knee replacement surgery. Probabilities have been assigned to each branch of each chance node. The patient's valuations of outcomes (measured in years of perfect mobility) are assigned to the tips of each branch of the tree.

Recovering full function after surgery (*p [full recovery] =0.60) and the chance of developing* infection in the prosthetic joint (*p[infection]=0.05).* Uses our subjective estimate of the probability that the patient will die during or immediately after knee surgery (*p [operative death] =0.05).*

Figure 9 Decision tree exam

Calculate the expected value, in healthy years, of surgery and of no surgery

The calculation requires three steps:

Node A:

1. Calculate the expected value of operative death after surgery to remove an infected prosthesis. Multiply the probability of operative death (0.05) by the outcome—death (0 years). The resulting measure is called a **quality-adjusted life year (QALY)** 0.05 × 0 = 0 QALY

2. Calculate the expected value of surviving surgery to remove an infected knee prosthesis. Multiply the probability of surviving the operation (0.95) by the number of healthy years equivalent to 10 years of being wheelchair-bound (3 years): 0.95 × 3 = 2.85 QALYs.

3. Add the expected values calculated in step 1 (0 QALY) and step 2 (2.85 QALYs) to obtain the expected value of developing an infected prosthesis: 0 + 2.85=2.85 QALYs [9].

Node B:

Similarly, the expected value at chance node B is calculated: (0.6 × 10) + (0.4 × 6) = 8.4 QALYs

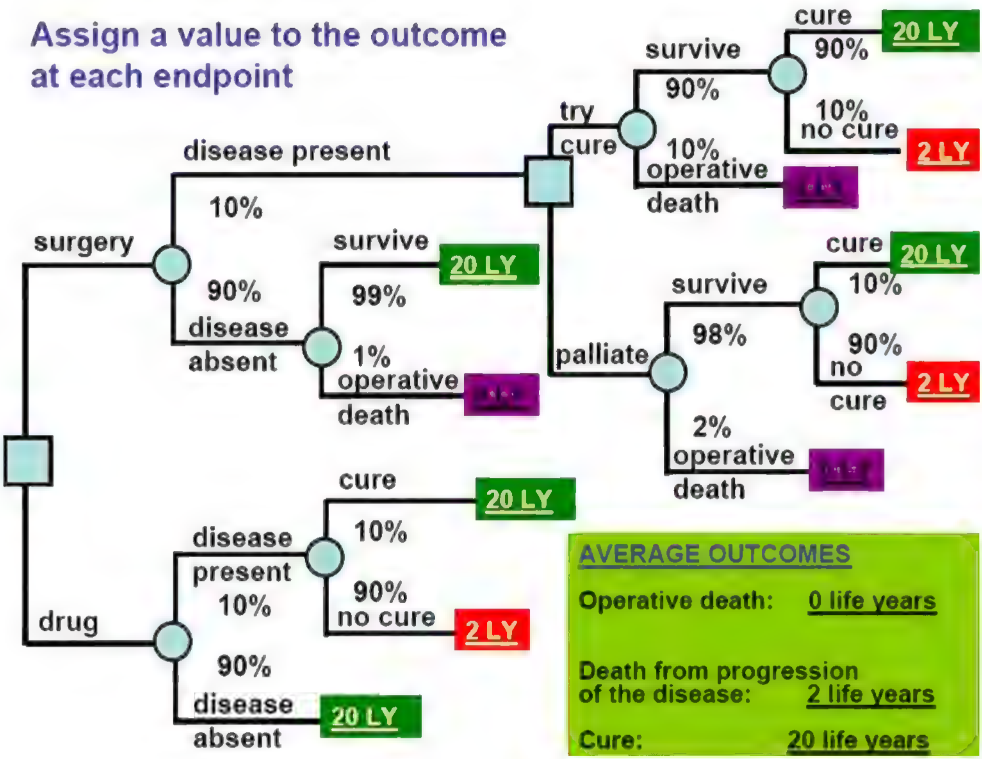


Figure 10 decision tree assignment

10. - Build-a-Tree Exercise: Construct a decision tree for a medical scenario (e.g., 'Treat vs. No Treat').
🧮📱 *QALY Calculator: Provide variables and ask readers to calculate expected values at each node.*

8. Legal, Ethical, and Security Issues:

Ethical health and privacy protections both provide valuable benefits to society. Protecting patient data requires careful attention to legal, ethical, and security considerations. Key aspects include adhering to privacy laws like HIPAA, implementing data encryption and access controls, and using health data ethically. These considerations ensure patient privacy, data security, and responsible data usage within the healthcare context. Important considerations:

8.1. Legal Considerations:

- **Patient Privacy Laws (e.g., HIPAA):** The Health Insurance Portability and Accountability Act (HIPAA) sets national standards for protecting individually identifiable health information (protected health information or PHI).
- **Data Security Rule:** The HIPAA Security Rule outlines standards for protecting electronic protected health information (ePHI).

8.2. Ethical Considerations:

- **Data Security and Privacy:** Protecting patient data from unauthorized access, misuse, or disclosure is paramount.
- **Informed Consent:** Obtaining informed consent from patients before using their data for research or other purposes is crucial.
- **Data Minimization:** Collecting and using only the minimum necessary data required for a specific purpose helps protect patient privacy.
- **Transparency:** Being transparent about data usage, including how it will be used and with whom it will be shared, builds trust with patients.

8.3. Security Considerations:

- **Data Encryption:** Protecting data through encryption, both in transit and at rest, is essential for data security.
- **Access Controls:** Implementing robust access controls, ensures that only authorized personnel can access patient data.
- **Physical Security:** Securing physical locations where data is stored, such as server rooms, is also vital.
- **Regular Security Audits and Updates:** Regularly auditing security measures and implementing necessary updates to protect against vulnerabilities is important [10].

11. 🔍📁 Case Review: A hospital leaked 10,000 patient records. What legal and ethical violations occurred?
✅📝 Checklist: Is your clinic compliant with HIPAA-like standards? Tick off the necessary elements.

9. Conclusion and Future Outlook:

HMIS is an essential tool in modern healthcare management. With proper implementation, it enhances efficiency, accountability, and patient outcomes. HMIS empowers healthcare professionals and administrators to make informed decisions and improve the overall quality of care.

- Enhanced Efficiency: HMIS streamlines administrative, clinical, and financial workflows, reducing paperwork, improving data access, and enabling quicker decision-making.
- Improved Patient Care: By centralizing patient information and providing real-time access to vital data, HMIS facilitates better diagnosis, treatment planning, and overall patient care.
- Increased Accountability: HMIS allows for tracking and monitoring of patient care activities, providing valuable insights into resource utilization, performance metrics, and potential areas for improvement.
- Data-Driven Decision Making: HMIS generates comprehensive reports and analytics, enabling healthcare organizations to identify trends, evaluate program effectiveness, and make data-driven decisions for future planning and interventions.
- Public Health Planning: HMIS data can be used for broader public health planning and research, helping to identify disease patterns, track health outcomes, and develop targeted interventions.
- Integration with Other Systems: Modern HMIS systems often integrate with electronic health records (EHRs) and other healthcare information systems, creating a more seamless and interconnected healthcare environment [11].

12.🧠Reflection Prompt: What do you think is the future of HMIS in your country?
🎯🖼️ *Vision Board (digital or paper): Ask readers to draw/write what an ideal health data system would look like.*

1. Foundational Concepts

- Concept Map: Link data → information → knowledge → decision-making → HMIS outcomes.
- Reflection: In a clinic, large volumes of patient data were recorded, but no system existed to summarize trends—leading to missed diagnoses. A dashboard could have identified these issues earlier.

2. Management Cycle

- Order: Situation Analysis → Objectives → Strategy → Plan of Activities → Monitoring → Evaluation.
- Case Focus: Likely on 'Monitoring' or 'Evaluation' stages to identify drop-off causes.

3. Information Sources

- Primary: Census, Surveys, Patient Registers. Secondary: Program Statistics. Administrative: Registrations, Mortality.
- Research: e.g., Somalia has gaps in digitized birth/death registries in rural areas.

4. HMIS Architecture & Building Blocks

- Labels: 1) Service Delivery, 2) Health Workforce, 3) Health Information Systems, 4) Medicines, 5) Financing, 6) Governance.
- Discussion: 'Health Information Systems' is most challenging in low-resource settings due to infrastructure limitations.

5. Strong HMIS Characteristics

- Checklist: Yes—Data modules, Secure databases, Reporting dashboards. No—Not all systems integrate EHRs or use Strategy Plans.
- Match: Dashboards → Monitoring; EHR integration → Interoperability; Secure DB → Privacy.

6. Immunization Data

- Example Data: Target = 100, Penta1 = 90, Penta3 = 80, Measles = 85. Dropout Penta1→Penta3 = 11.1%.
- Scenario: Could be due to poor follow-up, staff shortages, or missed reminders.

7. HMIS Applications

- Case: Clinic A (paper) = delays, errors. Clinic B (EHR) = real-time data, better continuity. B performs better.

- Role Play: Create hands-on sessions, phased rollouts, peer support teams for training.

8. HMIS Challenges

- Match: User resistance → Training; Data redundancy → Integrated platforms; Security → Access controls.

- Example: In a certain district hospital, moving to DHIS2 cut transcription errors by 60%.

9. Diagnosis Evaluation

- Problem: TP=40, FN=10, TN=90, FP=5. Sensitivity = 80%, Specificity = 94.7%.

- Sketch: Show two overlapping circles; perfect test = no overlap; real = some false positives/negatives.

10. Decision Trees

- Tree: Surgery → Full recovery (60%, 10 QALY), Partial recovery (40%, 6 QALY); No surgery = constant 5 QALY.

- QALY: $(0.6\times10) + (0.4\times6) = 8.4$; surgery preferred over no surgery (5).

11. Legal, Ethical, Security

- Case: Violations = No encryption, poor access control, lack of consent. HIPAA breach.

- Checklist: Yes = Encrypted files, access logs, physical server security. No = No regular audit.

12. Conclusion and Outlook

- Reflection: In Somalia, HMIS will support mobile health tracking and disease surveillance in nomadic communities.

- Vision: A connected, mobile-friendly, secure HMIS dashboard accessible in all district clinics.

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